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Small Decentralized Energy Systems in Remote Areas – Practical Experiences

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25.04.2023, Munich

Facilitator

eclareon

Experience with Decentralized Energy Systems
Nepal, India, Zimbabwe, Togo and Ghana

People without access to electricity **worldwide**:
759 million (2019)

Access to electricity – **urban population – Peru**:
100 % (2020)

Access to electricity – **rural population – Peru**:
96,8 % (2020)

[www.worldbank.org, April 2023]

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Experience with Decentralized Energy Systems
Lophelling Boarding School (LSB) in Nepal

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Experience with Decentralized Energy Systems
Zimbabwe – Service and Maintenance – Responsible Persons

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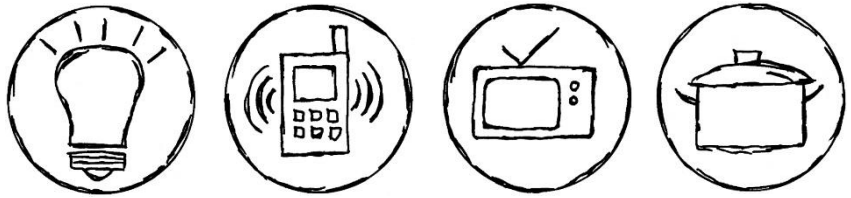
Typical Electrical Energy Demand
Results from Measurements, Surveys and Simulations

Household Category A

Power Peak: 0.1 – 0.2 kW

Energy Demand per Day: 0.3 – 1.0 kWh

Household Category B



Power Peak: 1.0 – 1.5 kW

Energy Demand per Day: 3.5 – 4.5 kWh

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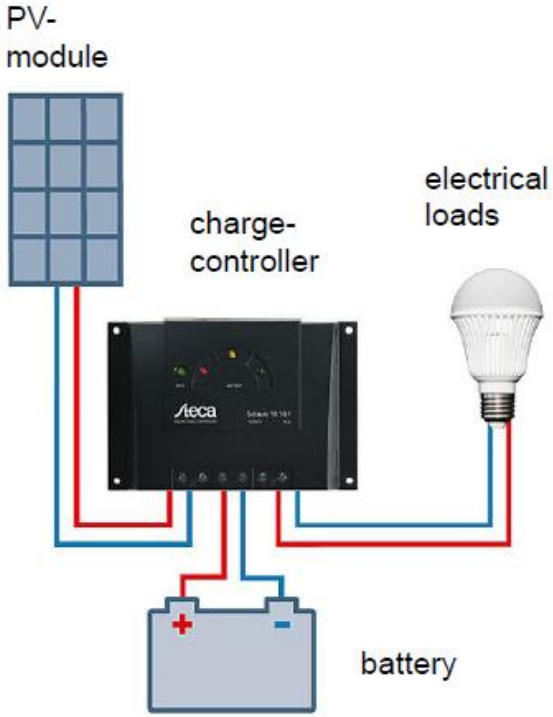
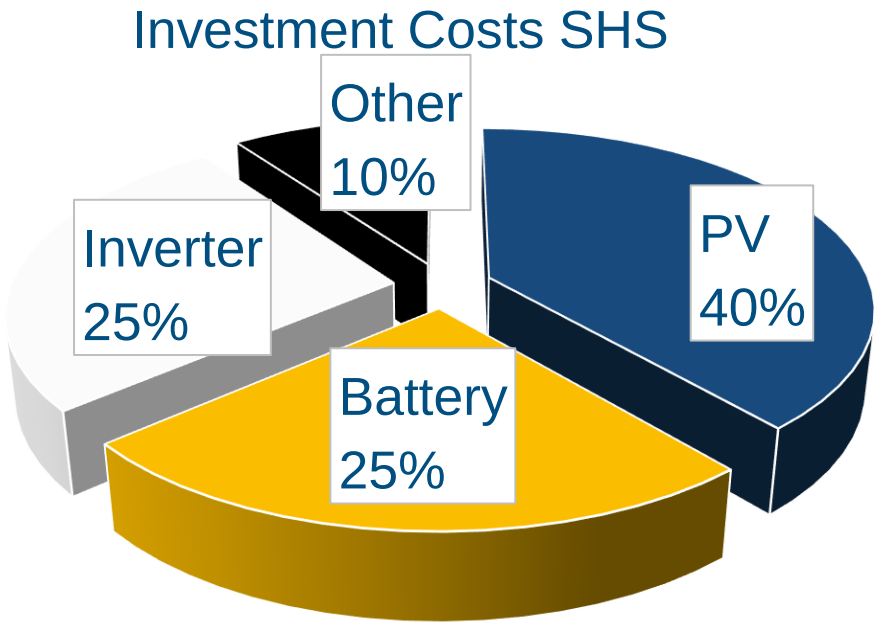
Small Decentralized Energy Systems (Solar Home Systems)
Central Role of the Battery System

[www.nytimes.com]



[www.steca.com]



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Lead-Acid Batteries or Lithium-Ion Batteries
Brief Comparison

	Lead-acid battery	Lithium-ion battery
Energy density	low	high
Efficiency	about 80 %	more than 90 %
Self-discharge	high	low
Safety	high	OK
Operational mode	robust, easy	battery management system (BMS)
Lifetime	5 – 10 years	15 – 20 years ?
Availability	worldwide	better and better, dev. countries?
Experience	high (150 years)	low
Costs	100 – 300 Euro/kWh	600 – 1000 Euro/kWh

Lead-Acid Batteries
Types – Open or Closed Design

Open lead-acid battery

- Liquid electrolyte
- Refill of battery water necessary
- Higher maintenance than closed Design

[www.conrad.de]

Closed lead-acid battery

- Gel- or fleece-Design
- Electrolyte fixed with silica (gel-Design)
- Electrolyte fixed with fleece (fleece-Design)
- Valve for overpressure
- Higher cost than open Design

[www.picclick.de]

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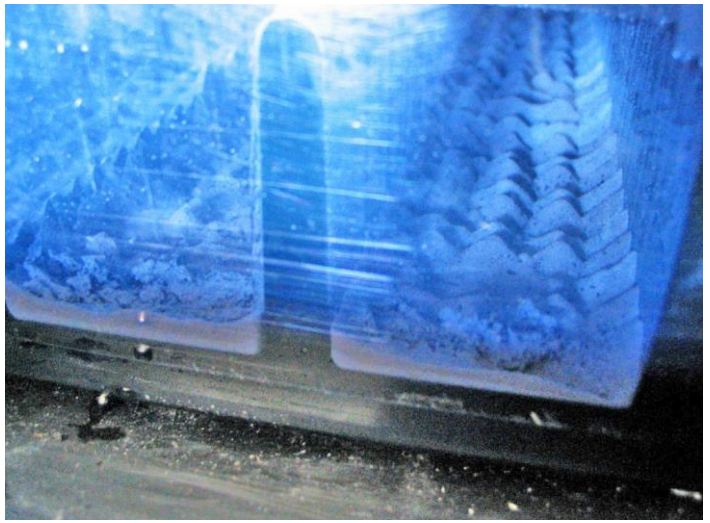
Lead-Acid Batteries
Aging Effect – Erosion

Reaction equation – lead-acid battery discharge:

$$PbO_2 + \mathrm{Pb} + 2H^+ + 2HSO_4^- \rightarrow 2PbSO_4 + 2H_2O$$

During a discharge process, up to 50% of the active material is converted from PbO_2 and Pb to $PbSO_4$.

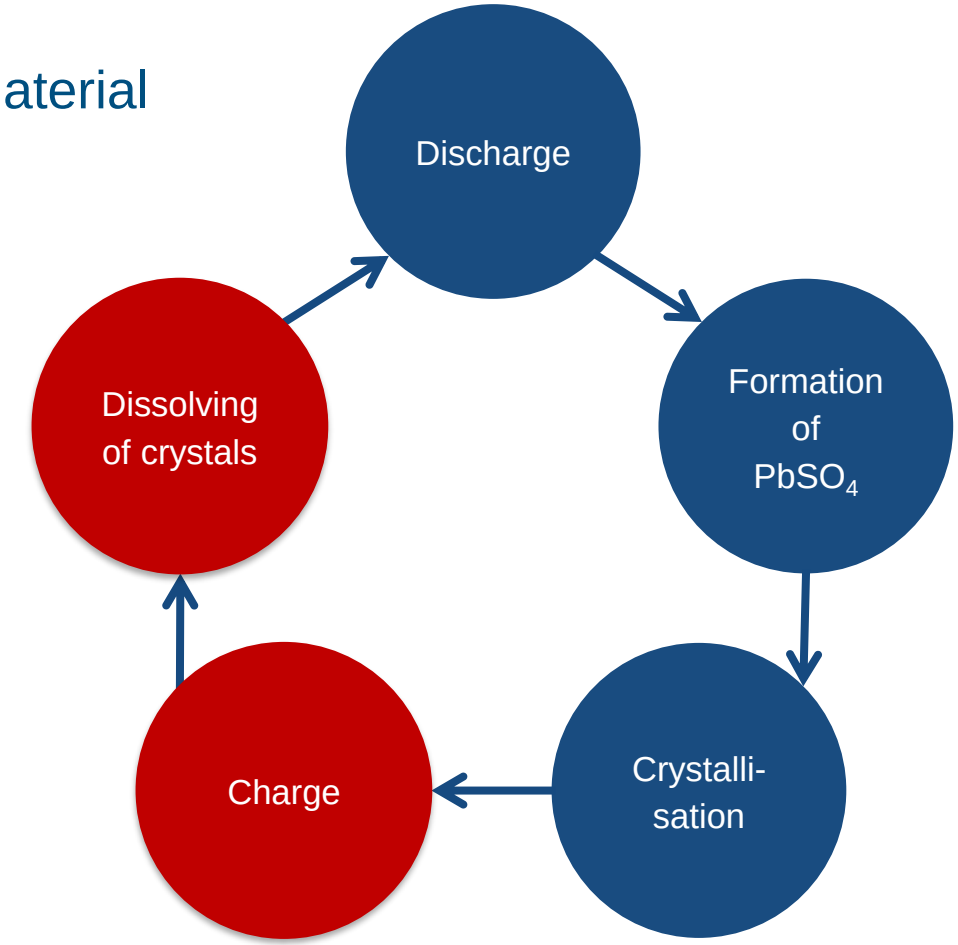
- Components have different volumes per mole
- Mechanical stress
- Loosening of active material
- Accumulation of active material in the bottom of the battery



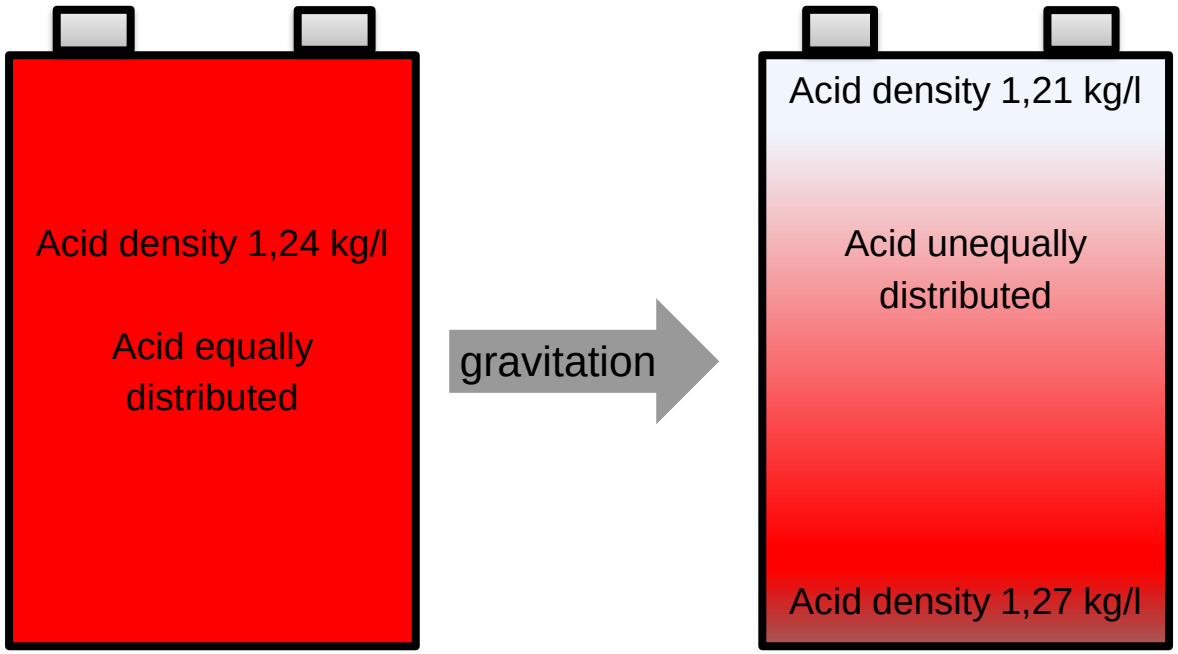
Lead-Acid Batteries
Aging Effect – Sulphation

During a discharge process, up to 50% of the active material is converted from PbO_2 and Pb to $PbSO_4$.

- ► Formation of lead sulphate crystals (about 1 µm)
- ► Circulation is disturbed by:
  - insufficient charge
  - extended duration in discharged state
- ► Lead sulphate crystals grow (about 10 µm)
- ► Incomplete dissolving of lead sulphate crystals
- ► Sulphation leads to loss of capacity



Lead-Acid Batteries
Aging Effect – Acid Stratification



Consequences:

- Increased charge in the upper part
- Increased discharge in the lower part
- Overcharge and deep discharge
- Fast sulphation and erosion in the lower part
- Fast aging in the lower part

Reduction:

- Open batteries (liquid electrolyte):
  scheduled overcharge or active electrolyte circulation (external pump)
- Closed batteries (gel or fleece):
  storage orientation

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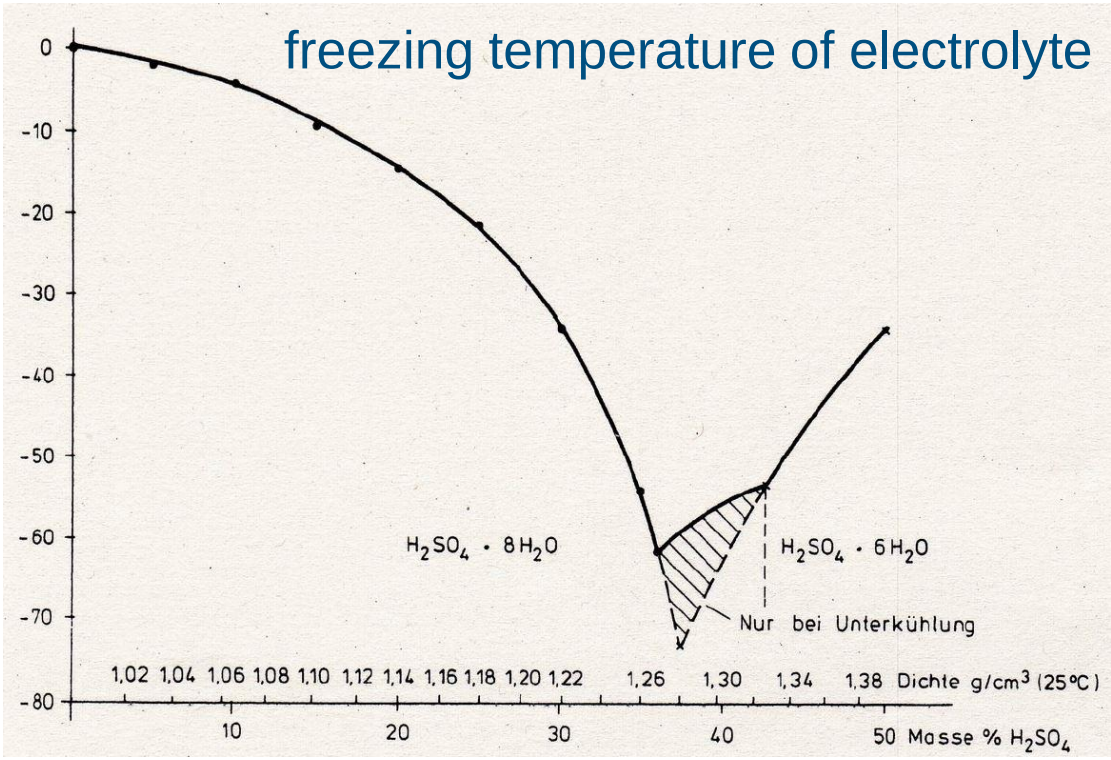
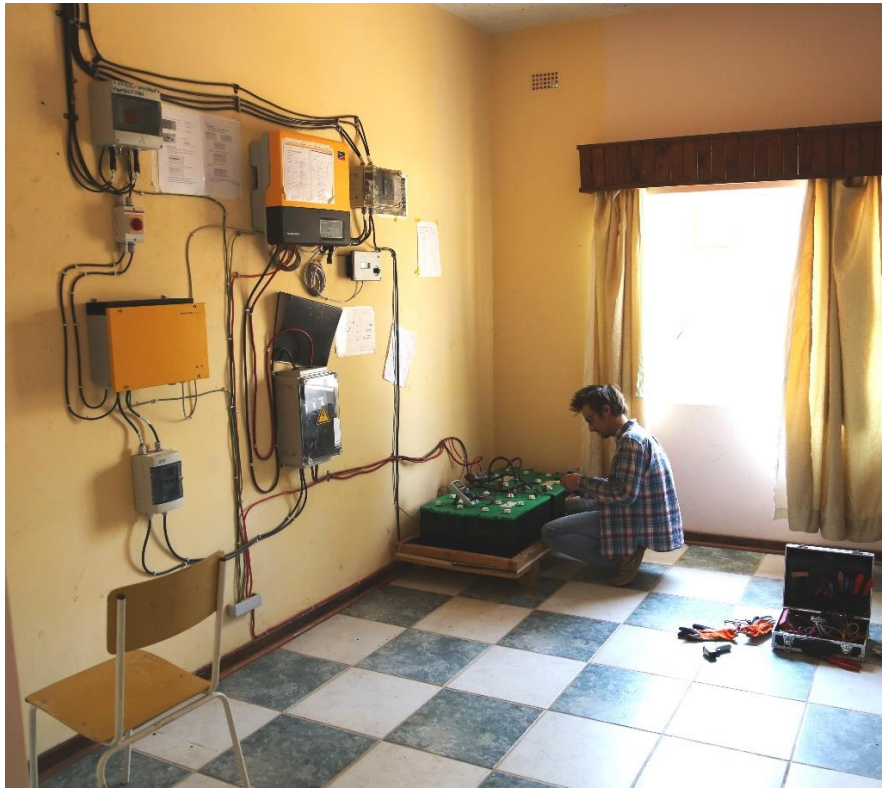
Lead-Acid Batteries
Operation at Low Temperatures



[D. Berndt, Bleiakkumulatoren, VDI-Verlag, Düsseldorf 1986]

Lead-Acid Batteries
Operation at High Temperatures



- Optimal battery temperature: 10 to 20 °C
- Increased ageing at high temperatures!
- Rule of thumb:

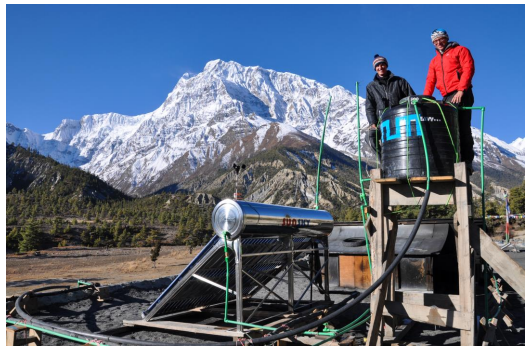
  10 °C temperature increase

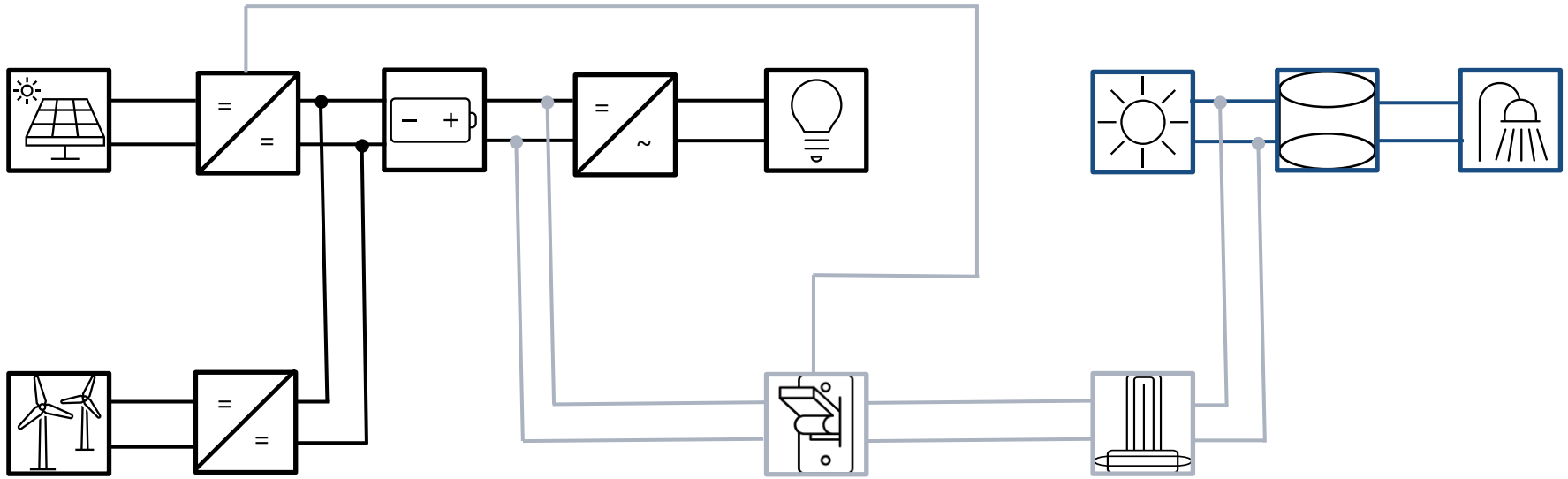
  ▼

  doubling of aging effect

  (lead-acid and lithium-ion batteries)
- Ventilated and cool location

Decentralized Energy Systems
Optimization with Sector Coupling – LBS Nepal





Experience with Decentralized Energy Systems
The Human Factor

Fundamental questions:

- Who is responsible?
- Suitable technology?
- Knowledge and education?

Knowledge transfer:

- Curricula
- Cooperations
- Job potentials
- Acceptance increase

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Thank you for your attention!

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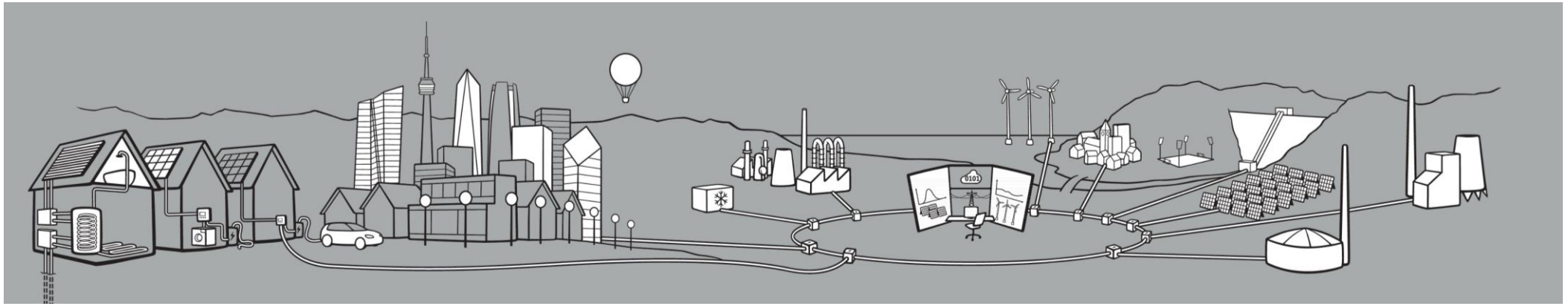

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